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Genetic variance in environmental sensitivity for milk and milk quality in Walloon Holstein cattle

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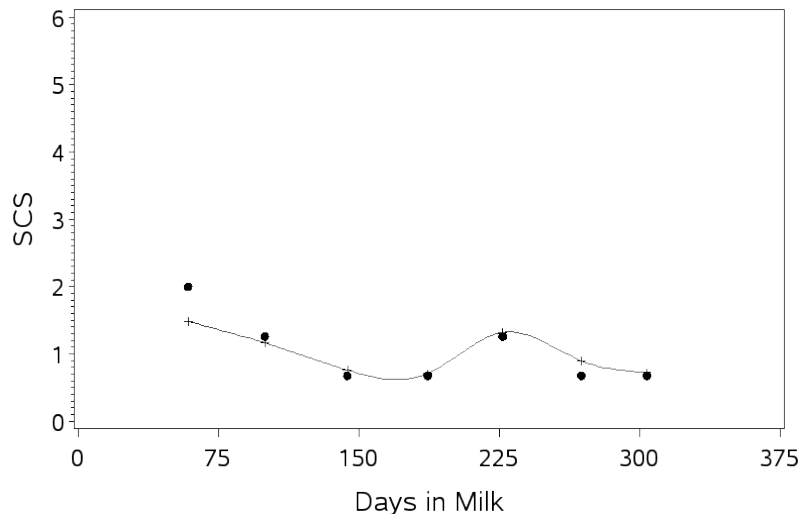
Introduction

- Dairy cows robust to environmental changes
 - Economically desirable for some traits (e.g., increase of homogeneity of dairy products)

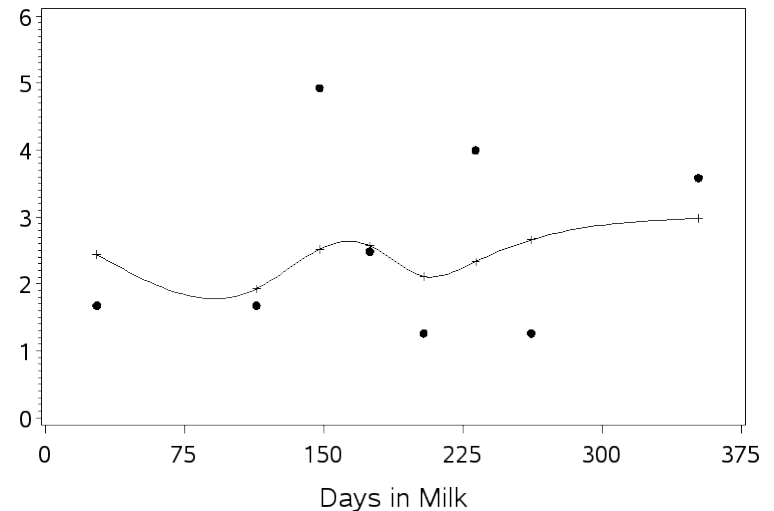
Introduction

- Dairy cows robust to environmental changes
 - Economically desirable for some traits (e.g., increase of homogeneity of dairy products)
- **But**, variations of observations around the fitted curve during the lactation:

Low variations



Large variations



Introduction

- Dairy cows robust to environmental changes
 - Economically desirable for some traits (e.g., increase of homogeneity of dairy products)
 - Environmental factors
 - Macro-environment
 - Identifiable (e.g., temperature)
 - Micro-environment
 - Unknown
- ➔ The genetic variance in micro-environmental sensitivity can be studied through genetic variance in residual variance (Hill and Mulder, 2010).

Introduction

- Potential interesting traits
 - Milk yield
 - Somatic cells score (SCS)
 - Milk fatty acids (**FA**) composition
 - Saturated FA (SFA)
 - Cholesterol, cardiovascular diseases (Haug et al., 2007)
 - Unsaturated FA (UFA)
 - Healthier for humans (Haug et al., 2007)
 - Milk fat quality properties (Palmquist et al., 1993)
 - C18:1 *cis*-9
 - Major UFA
 - Body fat mobilization in early lactation (Barber et al., 1997; Van Haelst et al., 2008)
 - ➔ poor fertility performances (Bastin et al., 2012)

Aim

To study genetic heterogeneity of residual variance for milk yield, SCS, SFA, UFA and C18:1 *cis*-9 separately

- Estimation of variance components and breeding values (EBV_v) in the residual variance part
- Using a double hierarchical generalized linear model (DHGLM; Rönnegård et al., 2010)

Data

- 26,887 Walloon Holstein first-parity cows
 - With a known sire
 - 747 herds
 - ≥ 5 cows / herd * test-day
 - ≥ 3 records / cow
 - 146,027 test-day records
 - Milk yield (kg), SCS
 - SFA (g/dL of milk), UFA (g/dL of milk), C18:1 *cis*-9 (g/dL of milk)
- Pedigree
 - 86,410 animals
 - ≥ 10 cows with records / sire

Model

- Mean model

$$y = X\beta + Zu + Zp + e$$

Fixed effects

- Herd * test-day
- Lactation stage (classes of 5 DIM)
- Gestation stage
- Age at calving * season of calving * major lactation stage (classes of 73 DIM)

Model

- Mean model

$$y = X\beta + Zu + Zp + e$$

Random effects

- Additive genetic
- Permanent environmental

Random residuals

Model

- Mean model

$$\mathbf{y} = \mathbf{X}\boldsymbol{\beta} + \mathbf{Z}\mathbf{u} + \mathbf{Z}\mathbf{p} + \mathbf{e}$$

- Residual variance model

$$V(\mathbf{e}) = \exp(\mathbf{X}_v \boldsymbol{\beta}_v + \mathbf{W}_v \mathbf{h}_v + \mathbf{Z}_v \mathbf{u}_v + \mathbf{Z}_v \mathbf{p}_v)$$

Fixed effects

- Herd * calving year
- Lactation stage
- Gestation stage
- Age at calving * season of calving * major lactation stage

Model

- Mean model

$$\mathbf{y} = \mathbf{X}\boldsymbol{\beta} + \mathbf{Z}\mathbf{u} + \mathbf{Z}\mathbf{p} + \mathbf{e}$$

- Residual variance model

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Random effects

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- Additive genetic
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Model

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$$V(\mathbf{e}) = \exp(\mathbf{X}_v\boldsymbol{\beta}_v + \mathbf{W}_v\mathbf{h}_v + \mathbf{Z}_v\mathbf{u}_v + \mathbf{Z}_v\mathbf{p}_v)$$

- Estimation of variance components and breeding values
 - DHGLM method (Rönnegård et al., 2010)
 - Iterations between the mean model and the residual variance model
 - Modified REMLF90 (Miształ, 2012)

Results

Trait	GCV	h^2_v
Milk yield	0.17	$1.99 \cdot 10^{-3}$
SCS	0.16	$3.47 \cdot 10^{-3}$
SFA	0.12	$1.01 \cdot 10^{-3}$
UFA	0.12	$3.57 \cdot 10^{-3}$
C18:1 <i>cis</i> -9	0.12	$4.17 \cdot 10^{-3}$

- **Low** genetic coefficients of variation for residual variances (**GCV**; \approx genetic SD of the residual variance model)
 - In the lower range of GCV for other species (Hill and Mulder, 2010)
- ➔ **Presence of some genetic variance in environmental sensitivity**

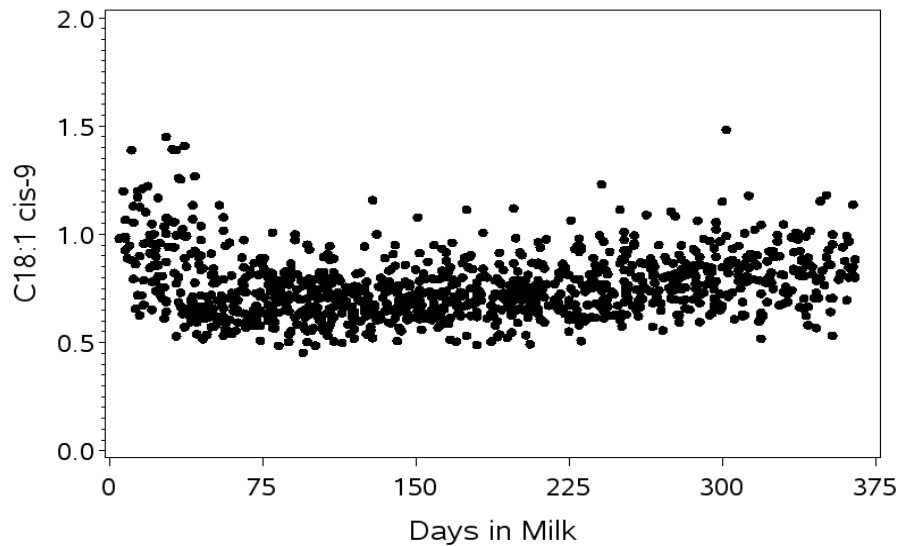
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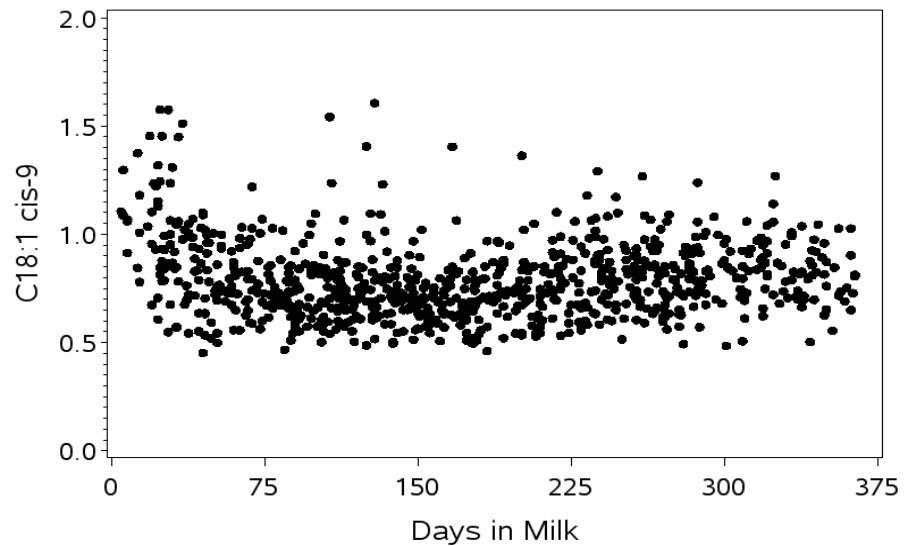
- Low heritabilities for residual variances (h^2_v)
 - ➔ Lower than estimates in other species (0.02-0.05; Hill and Mulder, 2010)
 - ➔ Accurate EBV_v estimated from a large data set with enough information per animal (Mulder et al., 2007)

Results

Low EBV_v sire



High EBV_v sire



- Low EBV_v sire: **less variation in observations** within its daughters group than the high EBV_v sire

Results

	Variance	Traits				
	components	Milk yield	SCS	SFA	UFA	C18:1 <i>cis</i> -9
Mean	σ^2_p	1.11	0.70	0.41	0.14	0.11
model	σ^2_u	0.57	0.15	1.34	0.30	0.20
Residual	$\sigma^2_{h_v}$	0.13	0.18	0.14	0.20	0.19
variance	$\sigma^2_{p_v}$	0.53	0.95	0.42	0.33	0.30
model	$\sigma^2_{u_v}$	$0.29 \cdot 10^{-1}$	$0.25 \cdot 10^{-1}$	$0.14 \cdot 10^{-1}$	$0.15 \cdot 10^{-1}$	$0.15 \cdot 10^{-1}$

- Herd * test-day and permanent environmental effects
 → Substantial contributions to heterogeneity of residual variance
- The DHGLM method may provide interesting information for management purposes in terms of variation.

Results

Pearson correlations between EBV and EBV_v

Milk yield	SCS	SFA	UFA	C18:1 <i>cis</i> -9
0.47	0.27	0.28	0.24	0.22

- Positive correlations
 - Higher EBV → higher EBV_v → ↑ residual variance

Results

Pearson correlations between EBV and EBV_v

Milk yield	SCS	SFA	UFA	C18:1 <i>cis</i> -9
0.47	0.27	0.28	0.24	0.22

- Positive correlations
 - Higher EBV → higher EBV_v → ↑ residual variance
 - Milk yield
 - Highest correlation

Results

Pearson correlations between EBV and EBV_v

Milk yield	SCS	SFA	UFA	C18:1 <i>cis</i> -9
0.47	0.27	0.28	0.24	0.22

- Positive correlations
 - Higher EBV → higher EBV_v → ↑ residual variance
 - Milk yield
 - Highest correlation
 - SCS
 - Selection of lower EBV would reduce the average level of SCS but also the residual variance of SCS, both involving fewer mastitis cases.

Results

Pearson correlations between EBV and EBV_v

Milk yield	SCS	SFA	UFA	C18:1 <i>cis</i> -9
0.47	0.27	0.28	0.24	0.22

- Positive correlations
 - C18:1 *cis*-9
 - Desirable: high contents in milk with few variation during the lactation
 - But, selection of low EBV_v would decrease the average content in milk of this FA.

Results

Pearson correlations between EBV and EBV_v

Milk yield	SCS	SFA	UFA	C18:1 <i>cis</i> -9
0.47	0.27	0.28	0.24	0.22

- Positive correlations
 - C18:1 *cis*-9
 - **Desirable**: high contents in milk with few variation during the lactation
 - **But**, selection of low EBV_v would decrease the average content in milk of this FA.
 - Correlations $\neq 1.00$
 - ➔ **Selection feasible** in a desired direction with proper weighting of both EBV in total merit indices

Conclusion

For all studied traits in the Walloon Holstein dairy cattle:

- Genetic and non-genetic heterogeneity of residual variance
- Genetic variance in environmental sensitivity
 - ➔ Selection feasible to change micro-environmental sensitivity
- Substantial contributions of non-genetic effects
 - ➔ Interesting information for management purposes in terms of variation

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